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SPECIAL FEATURES OF CORE DRILLING IN THE SALT BEDS OF WESTERN TEXAS AND NEW MEXICO

BY

JAMES S. WROTH

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SPECIAL FEATURES OF CORE DRILLING IN THE SALT BEDS OF WESTERN TEXAS AND NEW MEXICO[1]

By James S. Wroth[2]

INTRODUCTION

The Act of Congress approved June 25, 1926 (Public Act 424, 69th Congress), authorized joint investigations by the U. S. Geological Survey and the U. S. Bureau of Mines to determine "the location, extent, and mode of occurrence of potash deposits in the United States."

The particular deposits selected for exploration were the extensive rock-salt formations underlying large areas in western Texas and southeastern New Mexico, from which potash salts had been identified in the cuttings and sludges from oil wells drilled with cable tools. The evidence of these sludge samples was qualitative only and beyond definitely proving the presence of potash salts in the salt beds, gave little clue to the possible size, richness, or extent of the potash occurrences.

It was determined to secure more definite information with regard to these occurrences by exploring the saline formations with a core drill in order to recover a core which would give a complete cross section of the salt horizons with which the potash occurrences are associated. The Bureau of Mines was charged with the drilling at sites selected by the Geological Survey.

This paper is confined to a discussion of the methods employed in the diamond drilling and the special problems of recovering salt core, and will be limited strictly to the matter of drilling technique.

Development of Drilling Method

Prior to 1924 but three attempts had been made to core these salt deposits, and each of the three wells got into difficulties; two of them had to be abandoned before reaching

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2 - Mining engineer, U. S. Bureau of Mines.

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the salt horizons, and the third after penetrating the upper salts. A little later two diamond-drill holes put down in central Texas successfully penetrated the salt horizons but encountered many difficulties and recovered less than 50 per cent of the salt core. As a result of these attempts the general impression was created that the salt beds were very difficult, if not impossible, to core successfully.

During the summer of 1926, while the Bureau of Mines was preparing to start its drilling operations and was acquiring the necessary leases at the sites selected by the Geological Survey, the Snowden-McSweeney interests completed a diamond-drill hole on the McNutt permit in Sec. 4, T. 21 S., R. 30 E., Eddy County, N. Mex., from which the core recovery was approximately 80 per cent. The drilling of this well was the most successful attempt hitherto made to obtain core from the soluble salt formations and marked a most notable contribution to the technique of drilling and coring these formations. This contribution was the design of a double-tube core-barrel, a modification of the old standard double-tube barrel, to meet the special conditions of the salt coring. The use of the new core-barrel is no doubt responsible for the complete core recovery obtained on some later wells where this equipment was used; while the lack of it in drilling earlier wells and failure to adopt it in some of the later wells, are at least partly responsible for low core recovery.

As a result of the experience gained by the engineers engaged in drilling on this well, the benefits of which were freely given to the Bureau of Mines, the bureau was enabled to draw up specifications for their first well, which resulted in a very satisfactory operation.

Acknowledgment should be made here of the full and complete cooperation of the officials and engineers of the Snowden-McSweeney Co., and its successor in potash drilling, the American Potash Co. of New Mexico. Not only at the start of the drilling operations, but during the whole drilling campaign, the engineers of the American Potash Company of New Mexico and of the Bureau of Mines have cooperated in the free discussion of drilling problems and of methods for meeting and overcoming drilling difficulties.

The first well drilled by the Bureau of Mines was started on February 14, 1927, and the twelfth well was completed on May 20, 1929. The first three wells were cored from the surface, whereas subsequent wells were churn-drilled to the top of the salts and cored from there.

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The following table shows the performance on the twelve completed wells.

Well No.	Location	Total depth, feet	Footage drilled in overlying formations above salts: Feet	Core recovered feet	Core recovery per cent	Footage core drilled in salt formations: Feet	Core recovered feet	Core recovery per cent
1	Eddy County, N.Mex.	1847'-6"	779'-"	600'-10"	77.1	1068'-6"	999'-2"	93.5
2	Eddy County, N.Mex.	1101'-0"	330'-10"	232'-1"	70.1	770'-2"	760'-2"	98.7
3	Eddy County, N.Mex.	1501'-6"	429'-8"	275'-4"	64.1	1071'-10"	928'-1"	86.6
4	Ector County, Tex.	2098'-0"	[1] 930'-3			1167'-9"	1167'-9"	100.0
5	Crockett County, Tex.	1799'-2"	[1]1161'-4"			637'-10"	637'-10"	100.0
6	Upton County, Tex.	1500'-8"	[1] 436'-8			1064'-0"	1064'-0"	100.0
7	Upton County, Tex.	1230'-6"	[1] 445'-4"			785'-2"	785'-2"	100.0
8	Crockett County, Tex.	1000'-10"	[1]467'-10"			533'-0"	526'-5"	98.7
9	Regan County, Tex.	1700'-0"	[1]1104'-5"			595'-7"	595'-7"	100.0
10	Glasscock County, Tex.	1842'-0"	[1]1233'-0"			609'-0"	609'-0"	100.0
11	Crane County, Tex.	2070'-0"	[1]1081'-3"			988'-9"	988'-9"	100.0
12	Winkler County, Tex.	2752'-6"	1076'-6"			1676'-0"	1676'-0"	100.0
	Totals	20443'-8"	9,476'-1"			10967'-7"	10737'11"	97.91

[1] Churn-drilled with cable tools, no core taken or required.

Before passing to the details of drilling practice the conditions under which drilling operations were conducted will be outlined in a general way.

Selection of Drilling Sites

In selecting drilling sites, the Geologioal Survey was governed primarily by favorable potash showings in nearby oil wells and in areas where these showings occurred at moderate depths. In this way, limited areas were selected within which the exact location of the sites was determined by the practical matters of road conditions for the transport of drilling equipment and supplies, and the relative distance to fuel and water supply.

The drilling sites have been at distances of 10 to 30 miles from the nearest settlement or source of supplies. Road conditions over the area which has been drilled are only fair. The roads are, with the exception of the main highways, simply dirt tracks across the prairies. They are rough, but otherwise are passable for automobiles and loaded trucks. Transportation difficulties are frequent in wet weather when the roads are soft and trucks and cars easily mired, but as such conditions last only a few days at a time the maintenance of a small store of supplies at the drill, sufficient for a few days' operations, avoids delays due to wet roads. When a drill is being moved from one location to another under such conditions, it is of course necessary to wait until roads dry out.

Deep sand is the greatest handicap in transportation, but at only two locations were sandy roads a factor. At one location the use of tractors was necessary for moving the drill and equipment.

All wells have been drilled with steam power, and water supply has been an important item. In nearly every instance water from ranch wells has been obtainable within a few

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miles of the drilling location, and a string of small pipe and a gasoline pump at the well have solved the water problem. At some sites water has been found within a hundred feet or so of the surface, so that a well could be drilled at the location itself.

The quality of the water is usually very bad, and careful attention must be given to the boiler. Boilers are blown every day and thoroughly cleaned at least once every week. A boiler must be thoroughly reconditioned after each hole is completed. Three boilers were taken out of service on the 12 wells drilled, one of which blew up, fortunately without doing any other damage. On account of the danger of leaky flues, etc., boilers are usually placed at least 60 feet away from the drilling rig.

At one location, natural gas was available for fuel, but the other 11 wells were drilled by burning fuel oil under the boiler. This oil was transported from 3 to 30 miles by truck.

Drilling Specifications

All the wells have been drilled on contract awarded after competitive bidding on specifications sent out by the Bureau of Mines to prospective bidders.

A copy of the specifications on which the bids for Well No. 12 were based is given below:

1. The sole object of the drilling is to obtain satisfactory core of the formation with special reference to any potash contained therein, and everything possible must be done to attain this end.

2. This well, which will be known as Potash Well No. 12, shall be drilled to a depth of not less than 2,250 feet, nor more than 2,750 feet, unless a greater depth is desired by the Government and is so ordered, in writing, by the contracting officer. The depth to which churn-drilling may be employed is approximately 1,075 feet, at which depth coring shall begin.

3. That portion of the hole from which no core is desired may be drilled by any suitable method. That portion from which core is desired shall be drilled with suitable coring equipment and a double-tube core-barrel, constructed in accordance with the specifications set forth in paragraph 4, shall be used. In all core drilling, diamonds shall be employed as the cutting medium.

4. In order to minimize grinding and washing of the core, the core-barrel shall be provided with a ball-bearing, nonrotating inner tube, and shall be so designed that the wash solution is fed, through passages provided in the bit, to the cutting face without coming in contact with the core. The core-barrel shall be pulled and emptied at intervals of not more than 10 feet, or at shorter intervals if deemed necessary and requested by the Bureau of Mines engineer.

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5. The contractor shall provide equipment capable of recovering 2 1/2-inch core to a depth of 2,500 feet.

6. Coring shall start at a depth of approximately 1,075 feet, the exact point to be indicated by the engineer-in-charge.

7. Drilling in the salts shall be done with a core bit recovering a core not less than 2 1/2 inches in diameter.

8. The hole shall be cased down to the salt beds and all water sealed off before drilling in the salt is started.

9. A full-strength brine solution shall be in circulation in the hole before drilling in the salt is started. This solution shall be prepared as follows: To a saturated solution of sodium chloride add 3 pounds of magnesium chloride per gallon of water used in preparing the salt solution. In the preparation of this brine the grade of salt known as "meat salt" shall be used and shall be added in excess in order to insure saturation. This solution shall be provided by the contractor and shall be kept at full strength at all times. An extra supply of solution shall be kept on hand at all times from which to replenish the circulating solution as required.

10. All core recovered shall be turned over to the engineer-in-charge, at the drill, in suitable core boxes furnished by the engineer.

11. The contractor shall provide the Bureau's engineer or his representative every facility for inspecting the drilling, and sampling the sludge, if desired.

12. Measurement of the hole shall be from the original surface level of the ground to the maximum depth penetrated by the bit.

13. The contractor shall keep an accurate log of the hole and furnish the engineer with daily reports on Bureau of Mines forms provided by the engineer.

14. The engineer-in-charge and other Bureau of Mines and Geological Survey officials shall be permitted to secure meals at the commissary of the contractor.

15. A complete operating and cost record, giving detailed information as to labor employed, fuel and water and miscellaneous supplies consumed, diamond loss, equipment worn out and discarded, casing set, etc., shall be furnished the engineer-in-charge.

16. Payments will be made each month for 75 per cent of the work

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done during the preceding month. The 25 per cent withheld will be paid upon completion and acceptance of each hole and core: Provided, however, if when the hole is completed and the cores obtained therefrom are unsatisfactory and not acceptable to the bureau because, in the opinion of the bureau, the contractor has failed to exercise the necessary care and employ proper methods in drilling, this remaining 25 per cent shall be deducted, not as a forfeiture or penalty, but as and for damages sustained by the Government, which are hereby liquidated at that sum.

17. The contractor must start drilling operations within 30 calendar days after date of approval of contract by the Secretary of Commerce, and the hole must be completed within 90 calendar days from that date: Provided, however, the time for completing the drilling may, within the discretion of the Director of the Bureau of Mines, be extended.

18. On completion of the drilling, the contractor must completely plug the well with mud, gravel, or other suitable material, and suitable cement plugs, in accordance with instructions of the bureau's engineer.

Description of Equipment

The double-tube core-barrel referred to in paragraphs 3 and 4 is of the type developed during the drilling of the Snowden-McSweeney's McNutt well, previously mentioned. The modification of the old standard double-tube barrel was first suggested by Mr. Whitehead, the contractor on the McNutt well. His suggestion was improved by the superintendent in charge of the drilling, Capt. A. S. Ruellan, who had an experimental barrel built in a local machine shop for trial. He later submitted his sketches and specifications to the Sullivan Machinery Co., of Chicago, Ill., who built a core-barrel in accordance with his specifications which was used on later holes.

This type of core-barrel was put into service on the Bureau of Mines No. 1 well and, with minor modifications in certain details, has been used on all subsequent wells.

Figure 1, although not an exact drawing of the core-barrel in use, shows the essential features of this core-barrel, which is designed primarily to prevent the circulating solutions from coming in contact with the core.

The head of this barrel is of the standard type, with the inner barrel mounted on a ball-bearing swivel so that it rotates freely and independently of the outer barrel. The solution is fed to the space between the two barrels. In the usual double-tube core-barrel the solution feeds to the bit at the bottom of the inner barrel and, between this point and the face of the bit, flows down alongside the core. The length of core thus exposed to

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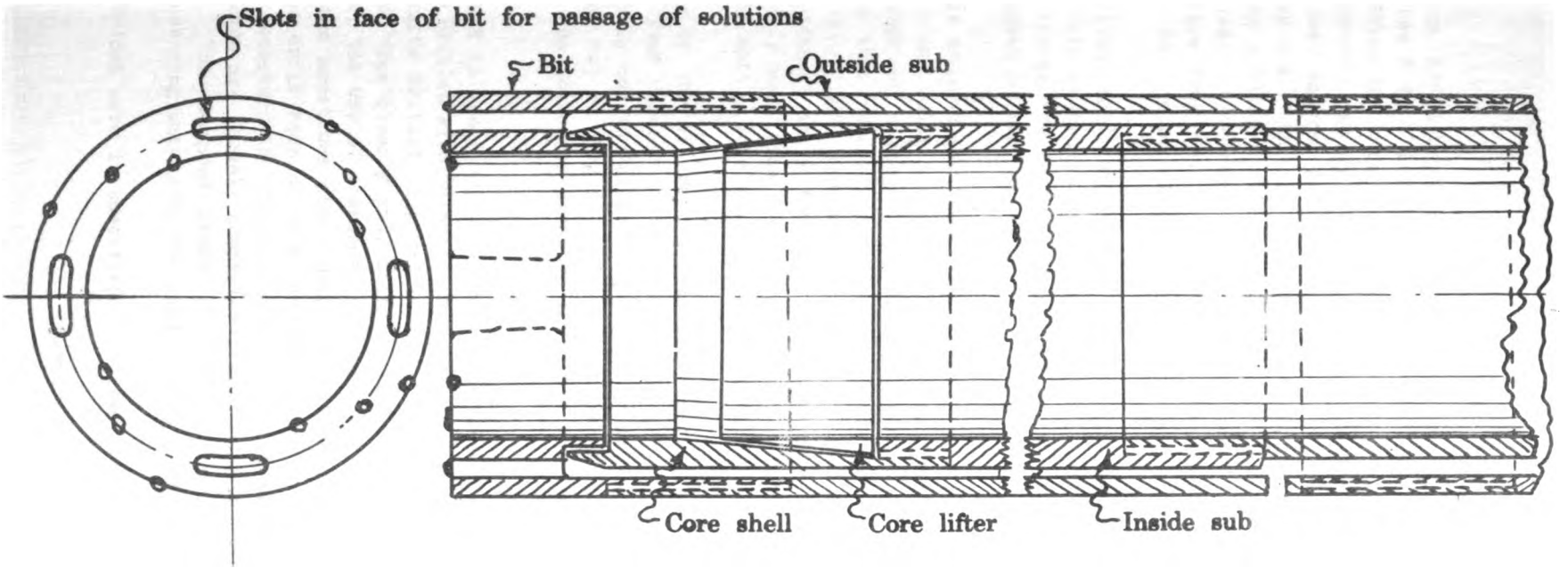

NOTE: This is a diagram to illustrate the principle and is not a drawing of an actual bit

Figure 1.— Sketch of bit end of double-tube core-barrel for salt coring

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the erosive action of high-pressure solutions issuing from the lower end of the inner barrel is thus from 2 to 3 inches. In soft formations and in some types of salt, this is sufficient to destroy the core, and even in the harder types of salt the result of this exposure to the high-pressure solutions is deep pitting and etching of the core, due, probably, to the increased solvent action of solutions under pressure. In the modified type of core-barrel, holes are bored in the bit and the drilling solution is made to feed through these holes to the cutting face of the bit without coming into contact, at any point, with the core. The clearance between the bit and the inner barrel is reduced to a point barely sufficient to allow free rotation--less than one thirty-second of an inch and in some barrels the inner tube is recessed into a ring cut into the bit.

Some solution, no doubt, escapes through this small opening, but the amount is very small, and when this opening is enlarged by wear, the effect on the core is immediately noticed. By replacing the core shell at the lower end of the inner barrel at frequent intervals, this space is kept as small as possible.

It will be noticed that short removable sections or subs are provided at the lower end of both inner and outer barrels. In removing the core from the barrel, the bit and outside sub are removed, exposing the core shell and about 10 inches of the inner barrel. The core shell is then removed from the inner barrel, and if the core has a tendency to stick in the barrel, light taps with a hammer on the inner barrel are usually sufficient to dislodge it, although it is sometimes necessary to dismount the whole barrel to recover the core, especially when fine shales, which have a tendency to stick in the barrel, are encountered in the salt. Some shale core recovered with this barrel was almost dry

The holes in the bit were originally one-fourth-inch round holes, but these have been replaced by four tapered slots, slightly larger at the bottom than at the top. Much of the salt is shaly and the holes frequently become plugged tightly with clay. The slots also tend to plug, but as they do so the pump pressure increases, due to decreased area of escape, and with the increased pressure the slots frequently clear themselves by "blowing" out the plug.

With regard to the cutting medium, the specifications call for diamonds. Several of the holes were drilled with sulamite, a tungsten alloy, set in the bits instead of diamonds. The sulamite drilled very well, but it had a tendency to tear the salt crystals rather than to cut them cleanly and, after a comparison of the cores obtained with diamonds and with sulamite, the use of diamonds was specified. The diamond-cut core is very cleanly cut, is smooth, and sometimes almost polished. The diamonds cut rapidly, often with only the weight of the drill rods on them, without using the pressure of the hydraulic, while it was sometimes necessary to "force" the sulamite bit in order to make rapid progress. In friable salts, which are loosely compacted large crystals, the superiority of the diamonds is unquestioned. The cheapest grade of diamond is used satisfactorily, and the diamond loss is small, occurring mainly in the hard anhydrite seams in the salt.

The 2-1/2-inch core is specified, for several reasons. It is large enough to give

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an excellent sample and small enough to be easily handled. In the beginning there was some uncertainty as to the ability of the salt core, especially those parts containing soluble potassium salts, to resist solution even in the concentrated drilling solutions used, and it was felt that with a 2-1/2-inch core considerable solution could take place and still leave sufficient core to yield a continuous cross section of the beds. There is vibration at the bit, and it was feared a smaller core would not have sufficient strength to resist shattering and breaking into short fragments at the bit. The 2-1/2-inch core has proved very satisfactory in every respect, and will continue to be called for.

Drilling Practice

All the wells are cased down to the top of the salts and upper waters sealed off before drilling in the salts is started. The salt formations are generally dry; in only one well have brines been found in the salts themselves, the other 11 wells being absolutely dry in the salt zone. The effect on the recovery of salt core of fresh water entering the well is obvious, and for the protection of the core while drilling, and in order to prevent the invasion of the salt formations by water from the upper levels, it is absolutely essential that all water, not actually occurring in the salts themselves, be completely and effectively sealed off. Usually the upper bed of the salt series is hard anhydrite, which provides an excellent horizon for setting casing and for sealing off the upper water. The use of cement in this anhydrite is usually not necessary to secure a tight joint, but in some instances it has been necessary to cement the well at the top of the salts. An effort is usually made to land a 6-inch casing at the top of the salts, which will leave room for two smaller strings of casing to be used if trouble is encountered in the salts. The decision as to what size of casing to land at the top of the salts is left to the contractor. In the well where brine was encountered in the salts, failure to land sufficiently large casing at the top of the salt series resulted in expense and loss of time to the contractor, who was compelled to ream the well and lower the casing through the brine-bearing horizon. In this case the brine was trapped between two narrow shale beds, while the balance of the salts were dry.

The drilling solution consists of a mixture of common salt and magnesium chloride. There is no stable, constant saturation point for these two chlorides occurring in the same solution. Solutions of these two salts will find their equilibrium points in accordance with the amounts of the two salts available for solution, and the conditions (temperature, etc.) at the time. The solution actually used is prepared by first making a saturated solution of common salt. This is done by adding about 3 pounds of salt to each gallon of water used. The grade of salt known as "meat salt" is specified, as it goes into solution much more readily than the coarse granular "ice cream" salt and is but little more expensive. The solution is agitated by a pump for 24 hours, or more, and enough salt is added to have an excess of salt present as a layer on the bottom of the mixing tank. To this salt solution is added 3 pounds of commercial magnesium chloride ($MgCl_2 6H_2O$) for each gallon of water originally used in preparing the salt solution. This is also agitated until dissolved. The addition of the $MgCl_2$ precipitates out some of the dissolved NaCl and the resulting drilling solution contains about 8 per cent $MgCl_2$ and 18.5 per cent NaCl. In such a solution, KCl is slowly soluble and $MgCl_2$ is thrown down. The rate of solution of

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the KCl is very slow, however, and the normal time of exposure of the core to the solution is only about an hour. The fact that KCl is dissolved is shown by the slight etching and pitting of the core when KCl is present; this etching is one of the most easily recognizable signs of the presence of KCl. It is possible that as drilling is carried on in the salts, some of the $MgCl_2$ in the solution is replaced by NaCl from the salt cuttings, but this type of solution has given very satisfactory results in preserving the soluble potash salts present in the core. The common salt in the core is untouched by this solution.

Due to the presence of fine shale in the salts, this solution has a muddy appearance on issuing from the well; the mud, however, seems to "float" on the surface of the solution in the sump tanks, so that if the solution in the sump is not agitated it soon becomes quite clear, as the mud either settles or floats.

In practice the top of the 6-inch casing in the well is provided with a tee below the drill platform. The solution from the well does not rise to the collar of the casing but flows through the tee and a pipe connection to a sump tank. This tank also serves as a partial clarifier, and the solution flows from this tank to a smaller pump sump, from which it is pumped into the well again. The flow from the large sump to the pump sump is controlled by a valve. A typical set-up is shown in plan in Figure 2. The rate of solution flow is determined by serveral factors--the size and total length of the rods through which it is pumped, the pressure at which the pump operates, and the number of holes in the bit which become plugged with clay. The rate of flow varies so widely that no figures can be given. The only essential is to have a constant supply of solution feeding to the face of the bit. As the core-barrel is only one-sixteenth to one-eighth inch smaller in diameter than the hole, depending on the clearance given the diamonds in the bit, only a small volume of solution is required to wash away the cuttings. The friction of this heavy solution, through 1,000 to 2,000 feet of drill rods and through the core-barrel and bit, calls for a pump capable of fairly high pressures. Various standard makes of pumps have given satisfaction. The grit in the solutions is hard on the moving parts, and frequent renewals are rquired in order not to lose pump pressure.

The core-barrel will hold 16 feet of core, and when drilling and core recovery are proceeding satisfactorily as much as 15 feet are drilled without pulling the barrel. Of course, shorter runs are frequently made where the core-barrel "blocks" or where the formations are difficult and shorter runs are called for. The driller can tell at once when the core-barrel is full or blocked and pulls it immediately. The best practice is never to fill the barrel completely, as sometimes pressure on the core in the barrel crushes it.

The core lifter does not always break the core just at the bottom of the well. Sometimes as much as 3 feet of core is left standing in the hole. This is seldom lost, as the next run of the tools slips down over this stub and recovers it. Thus it frequently happens that a run of 14 feet will yield only 12 feet of core, while the next run of 12 feet will yield 14 feet of core--the excess being the stub left from the last run.

The driller in charge of each shift is responsible for the core recovered on his shift. A core receiving box has been found convenient in the handling of the core. This

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consists of an open box about 16 to 18 feet long by 3 1/2 or 4 inches in cross section, which is sometimes lined with a sheet-iron trough. As the core is removed from the barrel each piece is laid in this box, care being taken not to reverse the position of any of the pieces. The core is measured and inspected by the driller as it lies in this box, and after his report is made it is transferred to the regular core boxes.

The core boxes used are 5 feet long and of sufficient width to hold 25 feet of core. Each section of core in the boxes is separated from the next by a five-eighths-inch board. The core is transferred from the receiving trough to the core boxes by the driller. The core is placed to "read" from left to right. The top of the core in each box starts at the upper left-hand corner, and the bottom is at the lower right-hand corner. As each run is placed in the boxes, it is marked by nailing a thin sheet-iron marker to the five-eighths-inch strips. These are placed at the end of the core from each run and are marked with tags. A sample tag is shown at B in Figure 3.

The boxes are numbered in order, with the tags shown at C in Figure 3.

When filled, the core boxes are removed to the core warehouse, which is the property of the Bureau of Mines and to which the drill superintendent, the U. S. Bureau of Mines engineer, and the representative of the U. S. Geological Survey have the only keys. The core is logged immediately by the Bureau's engineer, who notes principally the type of salt and indications of potash salts. The core is also available to the representative of the U. S. Geological Survey, who makes his own detailed stratigraphic log and selects the potash-bearing portions for shipment to the Survey's laboratories in Washington. If this selection is not made in the field, and it rarely is, the core boxes are sealed on completion of the well and shipped to the bureau's headquarters in Carlsbad, N. Mex., where they are held for the Survey's study and selection. The core not held for analysis or special study is thrown away.

A sample of the daily report in use is shown herewith (fig. 3A). This report form is possibly more detailed than is actually necessary. Where complete core is recovered the core is, of course, the best record of the well. This form was prepared during the drilling of Well No. 1, where considerable core was lost. The column "Drillers Comments" and the scale at the right were intended to supplement information furnished by the core, especially in those places where core was lost. Such information is very useful, but it is difficult to get the drillers to keep this sort of data; they are accustomed to depending on cores for their records. The report shows the record of each trip of the tools in and out of the well, and the trip numbers correspond with the numbers on the tags in the core boxes. This form can also be used as a record of churn-drilling operations.

Gas Pockets

Gas pockets are sometimes found in the salts. The gas in these pockets is mainly nitrogen and is found just beneath thin, impervious shale seams or beds of anhydrite. It is thought that the gas in these pockets is really air which was occluded in the salts at the time of their formation and which has been "squeezed" out of the salts by pressure and

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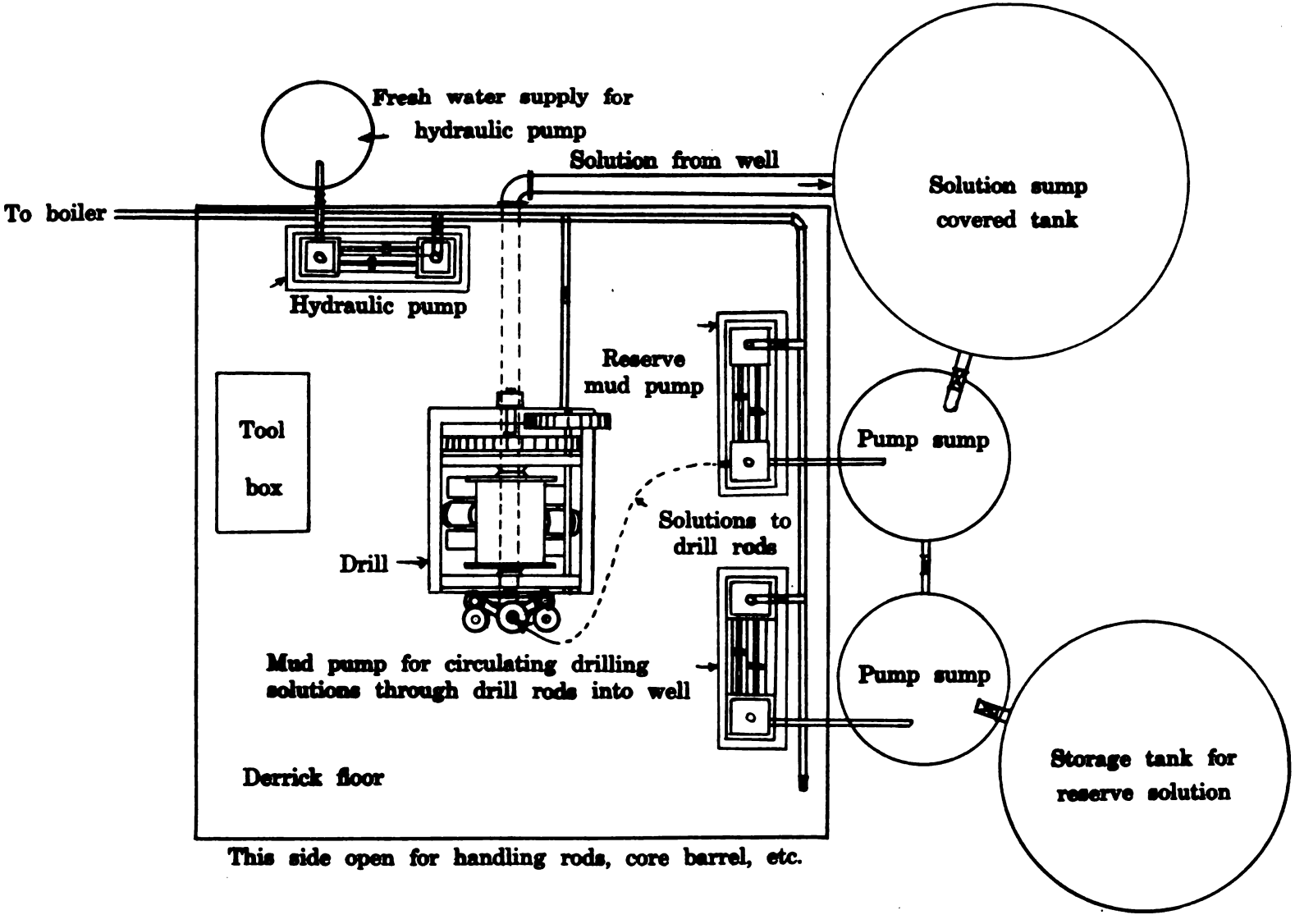

Figure 2. — Sketch plan of typical core drill layout for salt coring.
Not drawn to scale

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Form 440

BUREAU OF MINES
POTASH INVESTIGATIONS

(A)

REPORT OF CORE DRILLING PROGRESS

(One report for each shift worked)

TEST WELL NO. 12 DATE May 1- 1929 SHIFT Day / Afternoon / Night

TYPE OF BIT IN USE Diamond (Diamond, Dolomite, etc.) CORE BARREL: Single or double tube.

Depth of well at beginning of this shift 1902 Core recovered all

Feet drilled this shift 20 Core lost None

Depth of well at end of this shift 1922

Were tools in the hole and drilling in progress when shift ended? Yes. No.

TRIP RECORD

TRIP NO.	DEPTH AT START OF TRIP	FEET DRILLED	DEPTH AT END OF TRIP	CORE RECOVERED	DRILLER'S COMMENTS. Note any peculiarities in the drilling, such as soft or hard streaks, changes of formation, etc. Make check marks (√) at proper depths on scale at margin and comment below. Make every effort to determine depths where core is lost.	SCALE Sharp bar shows each foot drilled. Circles at start and end of shift
1	1902	15	1917	15	Salt	
2	1917	5	—	—		

Sample

NOTE.—When erecting rig, tearing down, reaming, setting casing, etc., enter rémand of the shift's work in the space above in lieu of the Trip Record.

Core from 1902 to 1917 placed in Box No. 31-33

from ..... to ..... placed in Box No. .....

from ..... to ..... placed in Box No. .....

(Signed) Edw. McGlovain
Driller.

Core lost: from ..... to ..... Reason .....

from ..... to ..... Reason .....

from ..... to ..... Reason .....

Drilling time lost 3 hours. Reason Packing pump

Equipment worn out, discarded, or taken out of service on this shift .....

Miscellaneous supplies consumed (Magnesium chloride, grease, oil, etc.) Mixed 600 lbs salt and 600 lbs Magnesium Chloride in 200 gallons

Remarks: of water.

Above report checked and approved as correct.

(Signed) Wm Martin
(In charge of operations for contractor)

(B)

DEPARTMENT OF COMMERCE
BUREAU OF MINES

DATE May 1 '29 TRIP No. 1

DEPTH 1917 feet

DRILLER Edw. McGlovain

(C)

DEPARTMENT OF COMMERCE
BUREAU OF MINES

WELL NO. 12 BOX NO. 33

CONTAINS CORE FROM 1902 FT. TO 1915 FT.

Figure 3.— *A*, Form of drilling progress report; *B*, core tag; *C*, core-box tag

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trapped beneath the impervious beds. Very high pressures are sometimes encountered, and when one of these pockets is struck the drilling solutions are often lost from being blown out of the hole. These pockets rapidly exhaust themselves and the flow of gas or air stops after a period varying from a few hours to as much as three days. One such pocket on a privately drilled well "blew" for two weeks, and operations were suspended until it had exhausted itself. The gas has very little odor.

One gas pocket on Well No. 4 was penetrated at about 1,500 feet, and gas bubbled from this well continously thereafter. The gas seemed to be confined in a thin bed of porous, spongy anhydrite. The volume of gas was small, so that drilling was not interrupted. The main source of trouble was the loss of drilling solution, which was lifted out of the well by the surges of gas. This difficulty was overcome by allowing the solution and gas to blow through the tee connection into a covered tank which had a vent in the top, while the rods operated through a reducer at the collar of the casing which held a rubber gasket as a stuffing box.

Porous Salt Formations

Another minor difficulty encountered on several wells was a porous salt formation from which no solution returned out of the well. The solution was absorbed by the porous salt or was lost in actual open cavities in the salt. One such open cavity, measured by the drop of the tools, was a foot in depth. When these conditions are met with, the hole must either be cased or cemented, although the use of thick mud fluid frequently is sufficient to seal off porous strata. Experience has shown that these porous strata and the open cavities are not usually very extensive, and that where mud fluid will not seal the porosities, cementing the well once or twice and drilling through the cement plug, is generally sufficient to restore the circulation. Where the salt is porous without open cavities a thick liquid cement lowered into the well usually suffices to seal the well; when open cavities are found, however, this procedure will not work, as the liquid cement drains away into the cavities. Where open cavities are found, they may be plugged by using cartridges of heavy paper, which are just small enough to slide through the hole and are 2 or 3 feet long. These cartridges are filled with dry cement and lowered to the bottom of the hole, where they are tamped with the drill rods. There is usually enough water in the well to soak into the cement and cause it to set. Water can be added, if necessary, but care should be taken not to wash the dry cement into the cavities. The hole is thus filled well above the point where trouble began, each cement cartridge being thoroughly tamped. Operations should be suspended for a time and the cement allowed to set. This, in the salt brines, requires three to four days, although some special quick-setting cement will set in the brine in 24 hours. The cement cartridges can be used in either a dry hole or a wet hole, but if in a wet hole they should be shellacked to prevent disintegration on the way to the bottom

It is important to make sure that the cement plug extends beyond those portions of the hole which are to be sealed. To accomplish this it is much better to lower the cement either in cartridges or, if liquid, in a special bailer made to fit the diamond-drill hole. Cement is sometimes pumped down the drill rods, but when this procedure is resorted to a

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thin mixture must be used and pump and rods must be immediately and thoroughly cleaned. Also, as cement settles slowly in heavy brine the rods must be kept very close to the bottom of the well, but if held in place too long there is some danger of sticking the rods.

When thoroughly hardened, as determined by soundings, the cement plug is drilled with the regular core bit. Usually a couple of feet of cement core only are taken, and the core is inspected for hardness. If satisfactory, drilling operations are continued beyond the cement plug, and if trouble is again encountered, about 6 feet of new hole is drilled and another plug set in place.

On one well, instead of losing solution it was discovered that more brine was coming out of the well than was being pumped in. In this case, cementing the well shut off the inflow.

Specifications for Core Warehouse

The core warehouse is built to provide sleeping quarters for the Bureau of Mines engineer when in the field. The house is of the portable type, 14 feet by 30 feet. It is built in panels, in accordance with the plan in Figure 4, and to comply with the following specifications:

Specifications for Field Office and Core Warehouse

Portable type. Walls, floors and roof to be built in sections or panels held in place by bolts. All panels of same size to be interchangeable. Panels to be plainly marked for assembly in accordance with attached sketch of floor plan and elevation and must fit properly. Structure to be weatherproof and strong enough to resist high winds.

Size ------- 14' x 30' outside dimensions x 9' ceiling in office.

Roof ------- ¼ pitch gable roof covered with slate coat composition roofing or its equivalent. Galvanized strips at edge and panel joints; must be waterproof.

Walls ------ 1" x 6" T. & G. material over building paper on 4" studs with base, top and panel trim.

Floors ----- In office, 1" x 6" T. & G. flooring over tar paper on 12" girders. Floor joists of sufficient strength to support 75 pounds per sq. ft. In warehouse, 1" x 12" plank on 12" girders. Joists of sufficient strength to support 150 lbs. per sq. ft.

Windows ---- Single sash, 4 light, not less than 32" square. Hinged or sliding sash in centers of panels. 7 windows in all.

Doors ------ Two four-panels standard pattern 2'8" x 6' 8" x 1-3/8".
One warehouse door, sliding 4' x 6'8" x 2" (double 1" plank).

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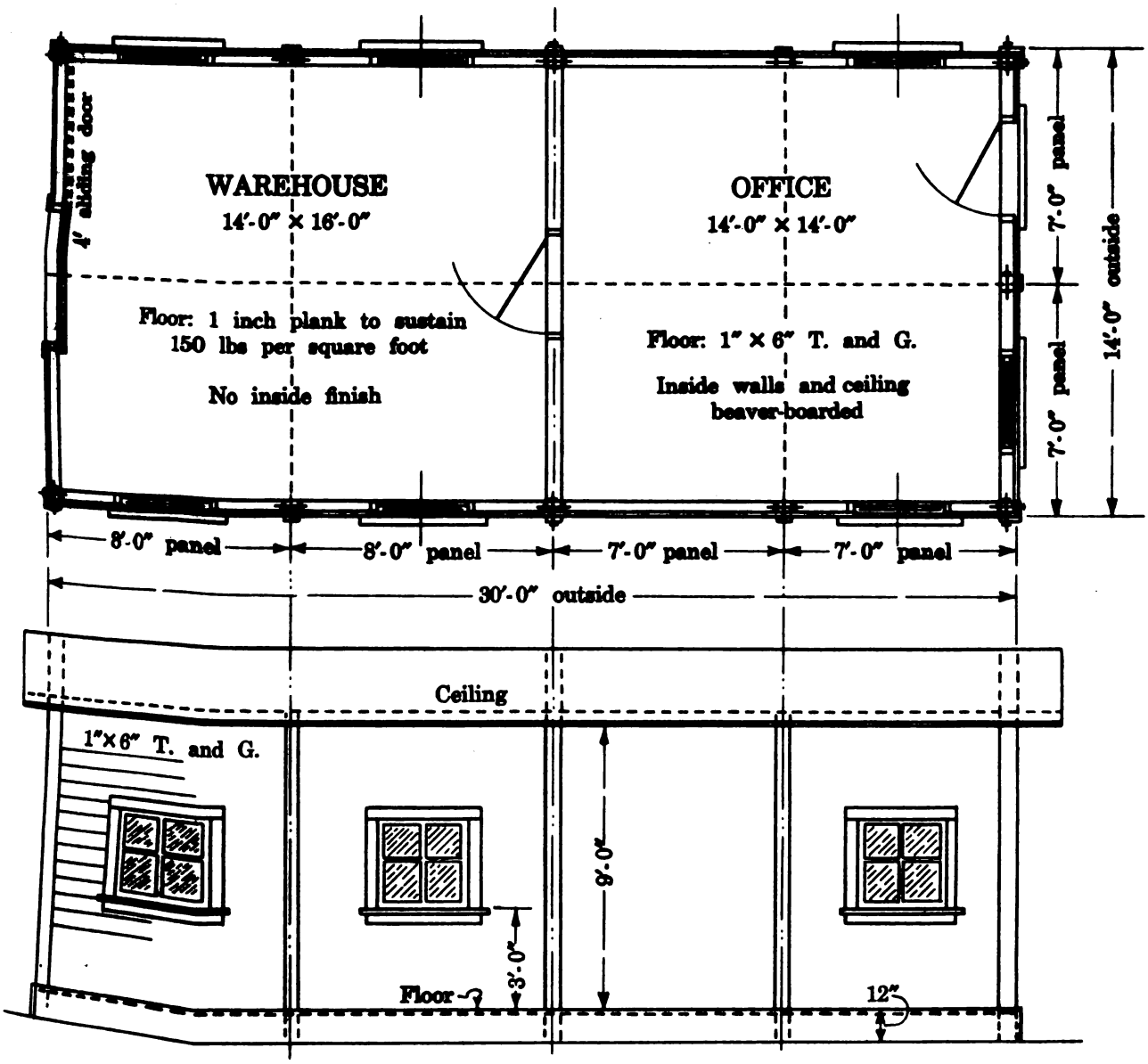

Figure 4. — Plan of core warehouse

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Partition — To extend to roof.

All lumber to be No. 2 fir or equivalent quality. Thoroughly dried and free from large or loose knots.

Gable panels to have stovepipe sleeves in each end.

Office finished inside with beaver board or similar material. No inside finish in warehouse.

All hardware of every description to be included.

To be painted, inside and out, with two coats of gray oil paint. Door, window, and panel trim painted red.

To be shipped crated. Will be assembled in the field by Bureau of Mines.

Quote crated ready for erection f.o.b. Artesia, N. Mex.
Bidders in Carlsbad and Roswell may quote f.o.b. their shops, if shipping weight and freight rate to Artesia are stated.

Drill holes are from 50 to 150 miles apart, so that the moving of drill, warehouse, and equipment is a large item of expense. The core house described above, weighing, when knocked down for shipment, 9,600 pounds, could be replaced by a lighter structure, but this type of portable house has given satisfactory service.

Summary of Drilling Performance

The following table gives a complete record of operations at each well, including the contract costs and average figures for the 12 wells drilled to date.

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Well No.	Location	Total Depth	Footage Drilled in Overlying Formations above Salt Series			Footage Core Drilled in Salt Formation			Casing Set Feet	CONTRACT COSTS								
							Core Recovered			Churn Drilling		Core Drilling				Casing	Total	
			Feet	Core Recovered	Per Cent Core Recovery	Feet	Feet	Per Cent		Amount	Per Foot	For Drilling Amount	For Core Recovered	Total Amount	Per Foot	Amount	Amount	Per Ft. of Total Depth
1	Eddy Co., N. Mex.	1847'-6"	779'-0"	600'-10"	77.1	1068'-6"	999'-2"	93.5	435'-8"	—	—	$19,398.75	$3,200.00	$22,598.75	$12.23	$635.50	$23,234.25	$12.58
2	Eddy Co., N. Mex.	1101'-0"	330'-10"	232'-0"	70.1	770'-2"	760'-2"	98.7	198'-10"	—	—	14,863.50	2,480.41	17,343.91	15.75	298.25	17,642.16	16.03
3	Eddy Co., N. Mex.	1501'-6"	429'-8"	275'-4"	64.1	1071'-10"	928'-1"	86.6	1210'-1"	—	—	20,270.25	3,008.65	23,278.90	15.84	1,815.13	25,094.03	16.71
4	Roter Co., Tex.	2098'-0"	*930'-8"	—	—	1167'-9"	1167'-9"	100.0	3094'-2"	$7,442.00	$8.00	14,013.00	2,335.50	16,348.50	14.00	3,094.17	26,884.67	12.80
5	Crockett Co., Tex.	1799'-2"	*1161'-4"	—	—	637'-10"	637'-10"	100.0	3675'-8"	8,129.33	7.00	9,895.20	2,128.00	12,023.20	11.30	1,336.17	15,673.70	10.44
6	Upton Co., Tex.	1500'-8"	*436'-8"	—	—	1064'-0"	1064'-0"	100.0	1536'-2"	2,314.33	5.30	7,302.05	1,570.33	8,872.38	11.30	1,416.17	12,648.82	10.28
7	Upton Co., Tex.	1230'-6"	*445'-4"	—	—	785'-2"	785'-2"	100.0	1416'-2"	2,360.27	5.30	5,223.40	1,052.83	6,276.23	11.80	1,434.50	10,190.25	10.18
8	Crockett Co., Tex.	1000'-10"	*467'-10"	—	—	533'-0"	526'-5"	98.7	1434'-6"	2,479.52	5.30	4,854.01	1,191.16	6,045.17	10.15	6,057.10	17,503.47	10.24
9	Regan Co., Tex.	1700'-0"	*1104'-6"	—	—	595'-7"	595'-7"	100.0	4326'-6"	5,401.20	4.80	4,963.35	1,218.00	6,181.35	10.15	6,477.10	18,576.85	10.08
10	Glasscock Co., Tex.	1842'-0"	*1255'-0"	—	—	609'-0"	609'-0"	100.0	4626'-6"	5,918.40	4.80	4,963.35	1,218.00	6,181.35	10.15	6,021.75	21,247.56	10.26
11	Crane Co., Tex.	2070'-0"	*1061'-3"	—	—	988'-9"	988'-9"	100.0	4301'-5"	5,190.00	4.80	8,068.31	1,977.50	10,036.81	10.15	5,871.00	26,637.25	9.68
12	Winkler Co., Tex.	2752'-6"	*1076'-6"	—	—	1676'-0"	1676'-0"	100.0	3914'-0"	4,844.25	4.50	12,570.00	3,362.00	15,922.00	9.50	5,871.00	26,637.25	9.68
Sub-total, holes 4 to 12		15,995'-8"	*7936'-7"			8057'-1"	8050'-6"	99.92	28,124'-8"			74,214.40	16,100.99	90,315.39	11.21	35,383.21	169,777.90	10.62
Totals		20,445'-8"	9476'-1"			10,976'-6"	10,737'-1"	97.91	29,969'-8"	$44,079.30	$5.56	$128,746.90	$24,790.05	$153,536.95	$12.27	$38,132.09	$235,748.34	$11.55

*Churn drilled with cable tools. No core required or attempted.

Well No.	Location	TIME DISTRIBUTION								CORE DRILLING							CORE DRILLING						
		Total Days on Site	Setting up, Plugging, Tearing down, etc., days	Available for Drilling		Actual Drilling Time		Misc. Delays		Date Started	Date Finished	Time Days	Actual Drilling Time		Footage Per Day of		Date Started	Date Finished	Time Days	Actual Drilling Time		Footage Per Day of	
				Days	Per Cent	Days	Per Cent	Days	Per Cent				Days	Per Cent	Total Time	Drilling Time				Days	Per Cent	Total Time	Drilling Time
1	Eddy Co., N. Mex.	64	16.5	47.5	100.0	29.0	62.6	17.7	37.4	—	—	—	—	—	—	—	Feb. 21, 1927	Apr. 9, 1927	47.5	29.7	62.6	38.9	62.1
2	Eddy Co., N. Mex.	53	13.0	40.0	100.0	18.0	47.0	21.2	56.0	—	—	—	—	—	—	—	May 1, 1927	June 9, 1927	40.0	18.8	47.0	27.5	36.5
3	Eddy Co., N. Mex.	98	15.7	82.3	100.0	21.6	86.2	60.7	73.8	—	—	—	—	—	—	—	June 22, 1927	Sept.12, 1927	82.3	21.6	26.2	17.6	67.7
4	Roter Co., Tex.	88	27.1	60.9	100.0	33.4	54.4	26.5	43.6	July 26, 1927	Aug. 10, 1927	15.9	10.4	65.5	58.5	89.5	Aug. 17, 1927	Sept.30, 1927	45.0	26.9	59.8	25.0	43.4
5	Crockett Co., Tex.	69	21.7	37.3	100.0	30.1	54.1	17.2	45.9	Oct. 20, 1927	Nov. 15, 1927	27.0	11.8	43.8	45.0	98.4	Nov. 22, 1927	Dec. 2, 1927	10.3	8.5	80.6	62.0	77.9
6	Upton Co., Tex.	42	15.2	26.8	100.0	16.0	59.8	10.8	40.2	Jan. 7, 1928	Jan. 13, 1928	7.0	3.7	52.9	62.4	117.9	Jan. 18, 1928	Feb. 2, 1928	19.8	12.3	62.2	53.9	86.7
7	Upton Co., Tex.	27	8.1	18.9	100.0	13.8	70.4	5.6	29.6	Feb. 15, 1928	Feb. 21, 1928	6.2	3.5	56.5	70.8	127.1	Feb. 24, 1928	Mar. 8, 1928	12.7	9.8	77.1	61.8	80.2
8	Crockett Co., Tex.	37	11.7	25.3	100.0	9.4	37.1	15.9	62.9	May 15, 1928	May 20, 1928	15.5	4.9	31.4	30.6	96.8	June 3, 1928	June 12, 1928	10.0	4.5	45.0	53.3	118.5
9	Regan Co., Tex.	58	22.7	29.3	100.0	19.8	67.6	9.5	32.4	Aug. 2, 1928	Aug. 25, 1928	20.8	12.7	61.1	59.5	97.4	Aug. 29, 1928	Sept. 6, 1928	8.5	7.1	83.5	71.7	85.8
10	Glasscock Co., Tex.	72	18.8	56.2	100.0	26.7	50.2	26.5	49.8	Sept.21, 1928	Nov. 1, 1928	42.0	17.9	42.7	29.4	69.0	Nov. 6, 1928	Nov. 17, 1928	11.2	8.8	78.5	54.4	69.2
11	Crane Co., Tex.	81	21.5	59.5	100.0	29.8	50.1	29.7	49.9	Dec. 10, 1928	Jan. 10, 1929	32.2	15.2	47.0	56.9	134.5	Jan. 16, 1929	Feb. 12, 1929	27.5	16.5	60.5	36.2	59.9
12	Winkler Co., Tex.	86	19.6	68.4	100.0	30.0	55.6	30.4	44.4	Mar. 6, 1929	Mar. 27, 1929	22.0	13.2	60.0	49.0	80.5	Apr. 1, 1929	May 20, 1929	46.4	24.8	53.5	36.1	67.5
Sub-total, holes 4 to 12		562	192.4	379.6	100.0	210.8	55.5	169.1	44.5			188.4	91.3	48.4	42.1	86.9			181.2	119.0	66.7	44.4	67.8
Totals		777	227.6	569.4	100.0	280.7	51.1	268.7	48.9										361.0	189.2	52.4	34.7	66.1

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